U S DEPARTMENT OF COMMERCE, PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
33942R002

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)
09/831507

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/BR99/00093	November 11, 1999	November 12, 1998

TITLE OF INVENTION
A SYSTEM AND A METHOD FOR PROTECTING AN ELECTRIC MOTOR AND ITS CONTROL CIRCUIT, AND AN ELECTRIC MOTOR

APPLICANT(S) FOR DO/EO/US --- Marcos Guilherme SCHWARZ, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ■ This is a FIRST submission of items concerning a filing under 35 U.S.C. 371.

2. □ This is a SECOND or SUBSEQUENT submission of items concerning a filing under 35 U.S.C. 371.

3. ■ This express request to begin national examination procedures (35 U.S.C. 371(f) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).

4. ■ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. ■ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
a.■ is transmitted herewith (required only if not transmitted by the International Bureau)b □ has been transmitted by the International Bureau (see Form 308) c. □ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. □ A translation of the International Application into English (35 U.S.C. 371(c)(2))

7. ■ Amendments to the claims of the International Application under PCT Article 19 (35 U S.C. 371(c)(3))
a.■ are transmitted herewith (required only if not transmitted by the International Bureau)
b. □ have been transmitted by the International Bureau.
c. □ have not been made; however, the time limit for making such amendments has NOT expired.
d. □ have not been made and will not be made.

8. □ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. □ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. □ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ■ An Information Disclosure Statement under 37 CFR 1.97 and 1.98. (w/ copy of PTO Form 1449)

12. □ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. □ A FIRST preliminary amendment.
□ A SECOND or SUBSEQUENT preliminary amendment.

14. □ A substitute specification.

15. □ A change of power of attorney and/or address letter.

16. ■ Other items or information:

a) PCT Request (Form PCT/RO/101)
b) Notification of Transmittal of the International Search Report or the Declaration (PCT/ISA/220);
c) International Search Report (PCT/ISA/210);
d) Notification of Transmittal of the International Preliminary Examination Report (PCT/IPEA/416);
e) International Preliminary Examination Report (PCT/IPEA/409) **including the amended claim set to be prosecuted;**
f) PCT Publ. WO 00/30243 with Search Report
g) PCT Written Opinion (Form PCT/IPEA/408)
h)Applicants' Reply to Written Opinion dated November 13, 2000
i) PCT Chapter II Demand (PCT/IPEA/401)

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U.S. APPLICATION NO. (if known, see 37 CFR 1.5)
09/831507

17. ■ The following fees are submitted:	CALCULATION	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO ..... $860.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) ..... $670.00 No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2) ..... $760.00 Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO ..... $970.00 International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $96.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$860.00	
Surcharge of $130.00 for furnishing the oath or declaration later than □ 20 □ 30 months from the earliest claimed priority date (37 CFR 1.495(e)).	$ -	

Claims	Number Filed	Number Extra	Rate		
Total Claims	9 - 20 =	-	x $18.00	$ -	
Independent Claims	3 - 3 =	-	x $80.00	$ -	
Multiple dependent claim(s) (if applicable)			+ $260.00	-	
TOTAL OF ABOVE CALCULATIONS =				$ 860.00	
Reduction by ½ for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				$ 0.00	
SUBTOTAL =				$ 860.00	
Processing fee of $130.00 for furnishing the English translation later than □ 20 □ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$ -	
TOTAL NATIONAL FEE =				$ 860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property. +				$ 0.00	
TOTAL FEES ENCLOSED =				$ 860.00	
				Amount to be refunded	$
				charged	$

a. ■ A check in the amount of $ 860.00 to cover the above fees is enclosed.
b. □ Please charge my Deposit Account No. 02-4300 in the amount of $____ to cover the above fees. A duplicate copy of this sheet is enclosed.
c. ■ The Commissioner is hereby authorized to charge any additional fees which may be required with respect to any deficiency in the above noted "Basic National Fee", or credit any overpayment to Deposit Account No 02-4300 .

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has *not* been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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SIGNATURE

Dennis C. Rodgers - 32,936
NAME REGISTRATION NO.

Date: May 10, 2001

Title: "A SYSTEM AND A METHOD FOR PROTECTING AN ELECTRIC MOTOR AND ITS CONTROL CIRCUIT, AND AN ELECTRIC MOTOR"

The present invention refers to a system and method for protecting a combination of an electric motor and its control circuit, which aims at detecting possible technical failures that cause the current to rise.

An electric motor basically comprises a rotor and a stator. In order for this motor to function, that is so say, for the rotor to start moving, voltage is applied to the stator, inducing the movement of the rotor.

Usually, the control of rotation speed of the motor is carried out by means of inverters, which in turn are formed from switches, as for instance a MOSFET (transistor).

The application of electric motors having controlled speed is widespread, being used, for instance, for driving compressors, household appliances, traction, etc.

Basically, when used in permanent-magnet motors without position sensors, the inverters are constituted by a set of diodes for branching the alternate voltage, from a control central that actuates the switches and a block responsible for detecting the position of the rotor by monitoring the voltages in the phases of motor, making a comparison between the monitored values. The control of the motor is carried out by modulating the voltage on the phase of the motor, which consists in applying and interrupting the voltage on the phases at a high frequency. By means of this modulation, it is possible to control the current supplied to said phases of the motor, and one can adjust it at the desired torque and speed for its operation.

In the case of induction motors, the position detector of the rotor is not used, the control of speed and torque being effected by modulating the voltage on the phases of the motor.

In both cases, a control central is employed, which is usually constituted by a microcontroller or a signal processor, which receives the external command for operation of the motor and starting from the monitoring of internal variables of the motor/inverter (current on the motor, position of the rotor, etc.), generating commands that supply voltage and current to the motor.

During the actuation and functioning of the motor, the current may undergo rises (or surge current) as a result of a overload or else as a result of a short circuit.

The rise of the current resulting from a overload does not immediately endanger the integrity of the motor and can be controlled. However, the current rise resulting from a short-circuit has a very rapid action, and so a protection mechanism should be actuated in order to prevent damage to the motor or the respective control circuit.

Description Of The Prior Art

The systems and methods for detecting surge current in electric motors known from the prior art usually actuate by using a predetermined current value, that is to say, a maximum current value is predetermined, so that the motor will not be damaged and, once this value is exceeded, a protection mechanism is actuated, protecting the motor or the respective control circuit. However, this protection method does not enable one to differentiate whether the current rise results from a overload or from a short-circuit, causing the protection mechanism to be actuated in either situations.

One prior art approach is disclosed in GB 2 267 190 and is related to a circuit breaker to shut down the power of an electric motor in the event of a failure. According to this solution, three separate circuits detect a slight-overload, a severe-overload or a short-circuit are connected to a led panel to indicate the type of problem that accrued.

Another related prior art is disclosed in US 4 558 264. According this document, an electric motor is controlled by measuring the electric current being applied. It is not foreseen a solution to protect the motor in case of an overload or a short circuit.

Short Description Of The Invention

The objective of the present invention is to provide a system and a method for detecting the occurrence of surge on electric motors and its control circuit, which will enable one to distinguish the occurrence of overload on the motor from a short-circuit, by using only a current detector adjusted to a preferred limit.

This objective is achieved by means of a system for protecting an electric motor and its control circuit, the control of motor speed being carried out by means of a set of switches, the system comprising a control central capable of measuring the electricity conduction time of each of the switches and to measure the time passed between the beginning of conduction of one of the switches and the occurrence of a surge, the central making a comparison of said times and being capable of determining whether said surge current results from a overload or from a short-circuit of the electric motor.

The present invention also refers to a method for protecting an electric motor and its control circuit, the speed control of which is effected by means of a set of switches, comprising a step of measuring the electricity conduction time of each of the switches, a step of measuring the time passed between the beginning of conduction of one of the switches and the occurrence of a surge current, and a step of comparing said times and consequently determining whether said surge current results from a overload or from a short-circuit on the electric motor.

In addition, the present invention refers to an electric motor, the speed control of which is carried out by means of a set of switches, the control of said switches being effected by a control central that is capable of measuring the electricity conduction time of each of the switches and to measure the time passed between the beginning of conduction of one of the switches and the occurrence of a surge current, the central making a comparison of the said times and being capable of determining whether said surge current results from a overload or from a short-circuit on the electric motor.

Brief Description Of The Drawings

The present invention will now be described in greater detail with reference to an embodiment represented in the drawings, in which:

- Figure 1 represents a schematic diagram of the speed control circuit of the motor and of the surge current detector according to the present invention;

- Figure 2 shows a temporal diagram representing the behavior of the current in a overload current situation;

- Figure 3 shows a temporal diagram representing the behavior of the current in a short-circuit situation;

- Figure 4 represents a flow-diagram of the method according to the present invention.

Detailed Description Of The Figures

The system for protecting an electric motor and its control circuit according to the present invention basically comprises a surge current detector 3, adjusted to a determined current limit.

Figure 1 schematically illustrates the motor 1 and the respective circuits for its control 2 and feeding. According to a preferred embodiment of the present invention, the motor 1 described will be of the three-phase type, which does not prevent the invention from being applied to another type of electric motor.

As can be seen from figure 1, the motor 1 and its control circuit 2 are fed by a source supplying alternate voltage that will be rectified by a set of diodes D and filtered by a capacitor C_1. A set of switches Ch1 - Ch6 is responsible for the modulation of the voltage on the phases F_1, F_2, and F_3 of the motor 1. The control of the set of switches Ch1 - Ch6 is carried out by a control central 7.

The detection of surge current is carried out by means of a surge current detecting circuit 3 that is connected to the control central 7, which measures the current I_{RS} that flows along the circuit through the resistor R_S, that is to say, the current that flows trough the switches Ch1-Ch6.

As illustrated in figure 1, the resistor R_S is installed in a position of the circuit that allows one to read the current I_M flowing through phases F_1, F_2, and F_3 of the motor, the current I_{RS} basically representing the current I_M.

The control central 7 emits commands for closing and opening the switches Ch1 - Ch6, besides receiving external information, such as the signal D_S, for instance. The signal D_S is generated by the surge current detector 3, when a predetermined I_{LIMIT} value (current limit) is exceeded.

The surge current detector 3 comprises an operational amplifier mounted as a voltage comparator C_O, the inlets of which are fed with voltages "E-" and "E+", wherein "E+" is the voltage of the first terminal of the resistor R_S, and "E-" is the voltage of the other terminal of this resistor R_S, plus an essentially constant voltage, defined by the voltage divider R_A and R_B. The $+V_D$ voltage is a constant.

The resistor R_1 causes the voltage variations on the resistor R_2 (represented by the current I_M of the motor) to be added to the constant voltage defined by the resistors R_A and R_B.

For a situation in which the current I_M flowing through the motor 1 is close to zero, the voltage "E-" is higher than the voltage "E+", thus causing the outlet D_S of the voltage comparator C_O to be at "low" level.

When the current though the motor 1 rises above a I_{LIMIT} limit defined by the resistors R_A, R_B and R_T, the voltage in the inlet "E-" becomes lower than the voltage in the inlet corresponding to a current value beyond the admissible limit, that is to say, above the I_{LIMIT} limit, thus characterizing the detection of surge current. In this situation, the outlet of the comparator C_O passes from "low" level to "high" level, signaling the occurrence of surge current to the control central 7 by means of D_S.

The differentiation between a overload and a short-circuit is made by measuring the rise variation time of the current I_{RS}, i.e., in the event of overload, the current rise occurs gradually, taking a relatively long period of time, until the I_{LIMIT} value is reached, whereas in the cases when the motor 1 enters into short-circuit, the I_{LIMIT} value is reached much more rapidly, thus enabling one to detect this kind of failure by measuring the time.

As already known from the prior art, the speed control is carried out by means of switches Ch1 - Ch6 and, as illustrated in figures 2 and 3, the switches Ch1,Ch4 conduct electricity for a determined period of time T_c that varies depending upon the rotation speed to be imposed to the motor 1.

In order to determine by means of the control central 7 whether the kind of failure on the motor 1 results from a overload or from a short-circuit, the present invention foresees the T_c-time and T_d-time measurement. The T_d-time is counted from the beginning of the conduction of the switches Ch until the moment when the current has reached the I_{LIMIT} value, that is to say, when the surge current occurred (see figures 2 and 3). The T_c time is the time of conduction of the switches Ch and depends upon the situation of motor operation (basically speed and load).

Figures 2 and 3 represent the temporal diagrams of the situations of overload and short circuit, respectively. By comparing the two diagrams, one can see in detail that, in the short-circuit situation, the current I_{RS} reaches the I_{LIMIT} value in much shorter T_d time when compared with the T_d time in the overload situation.

As can be seen from figure 4 schematically, the criterion used for determining whether the surge current results from a overload or from a short-circuit depends upon a relation between the T_d and T_c times. Thus, when the relation $T_d < T_c \cdot k$ is true, this means that the motor 1 is in short-circuit, and when the relation is false, this means that the motor 1

has undergone a overload. The measurement of the T_d and T_c times, as well as the comparison between the respective values is carried out by means of the control central 7.

The value of the constant k is a fraction or portion of the T_c value (being a number between 0 and 1), and defines the limit for the distinction of the kind of failure that occurred on the motor 1, and may vary depending upon the type of motor 1 in use, in addition to the protection level to be given to the latter.

For instance, if the value of k is 50% (or 0.5) and if the T_d time is short (shorter than 50% of T_c), this means that the motor 1 is in short-circuit, and it is necessary to add some protection mechanism in order to avoid damage to said motor 1. In the cases when T_d is longer (longer than or equal to 50% of T_c), this means that the motor 1 has undergone a overload.

Besides enabling one to differentiate the kind of failure occurred on the motor 1 or on one of the switches Ch1 - Ch6, the present invention further enables one to estimate the value of the surge that occurred on the motor 1 by evaluating the proportion T_d/T_c.

A preferred embodiment of the invention having been described, it should be understood that the scope of the present invention embraces other possible variations, being limited only by the contents of the accompanying claims, the possible equivalents being included therein.

Claims

1. A system for protecting an electric motor (1) and its control circuit (2),

the control circuit (2) comprising a set of switches (Ch) to control the speed of the motor (1)

the system being characterized by:

comprising a control central (7) connected to the control circuit (2), the central control (7) being capable of measuring an electricity conduction time (T_c) of each of the switches (Ch) and to measure a time (T_d) passed between the beginning of the conduction of one of the switches (Ch) and the occurrence of a surge current, the surge being measured by means of a surge detector (3) which compares the value of a current (I_{ms}) that flows trough the control circuit (2) to a predetermined current (I_{LIMIT}) value.

the central (7) making a comparison between the times (T_d, T_c) and being capable of determining whether the surge current results from an overload or from a short-circuit on the electric motor (1) or any of the switches (Ch).

2. A system according to claim 1, characterized in that the control central (7) indicates a condition of short-circuit of the motor (1) or on one of the switches (Ch) when the time (T_d) is shorter than the time (T_c) multiplied by a factor (k) that ranges from 0 to 1, and the central (7) indicates a condition of surge of the motor (1) when the time (T_d) is longer than the time (T_c) multiplied by the factor (k).

3. A system according to claim 2, characterized in that the factor (k) is equal to 0.5.

4. A method for protecting an electric motor (1) and its circuit (2),

the speed control of the motor (1) being carried out by means of a set of switches (Ch),

the method being characterized by comprising the steps of:

measuring an electricity conduction time (T_c) of each of the switches (Ch),

measuring a time (T_d) passed between the beginning of conduction of one of the switches (Ch) and the occurrence of a surge, and

comparing the times (T_d, T_c) and consequently determining whether the surge current results from an overload or from a short-circuit of the electric motor (1) or on any of the switches (Ch).

5. A method according to claim 4, characterized in that, in the comparison step, a condition of short-circuit of the motor (1) or on one of the switches (Ch) is indicated when the time (T_d) is shorter than the time (T_c) multiplied by a factor (k) that ranges from 0 to 1, and an overload condition of the motor (1) is indicated when the time (T_d) is longer than the time (T_c) multiplied by the factor (k).

6. A method according to claim 5, characterized in that, in the comparison step the factor (k) is equal to 0.5.

7. An electric motor (1) having phases (F),

the phases (F) being fed by a set of switches (Ch), and

the switches (Ch) being controlled by a control circuit (2) to modulate a voltage that is applied to the phases (F) to control the speed of the motor (1),

the motor (1) being characterized in that the control of the switches (Ch) is carried out by a control central (7) connected to the control circuit (2),

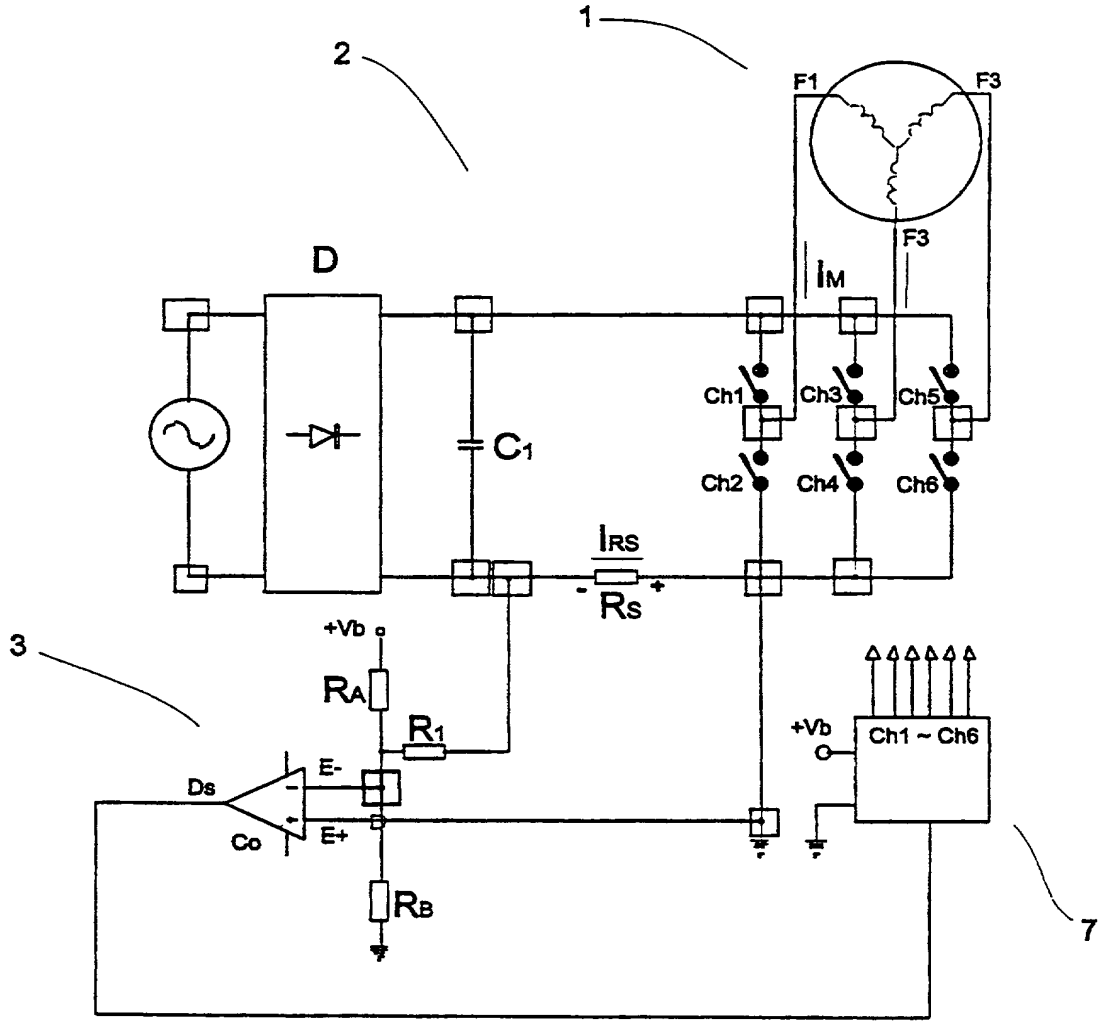
the control central (7) being capable of measuring the electricity conduction time (T_c) of each of the switches (Ch) and to measure the time (T_d) passed between the beginning of conduction of one of the switches (Ch) and the occurrence of a surge current,

the surge being a value of a current (I_{as}) that flows trough the phases (F) higher than a predetermined current (I_{LIMIT}) value,

the central (7) making a comparison between the times (T_d, T_c) and being capable of determining whether the surge current results from an overload or from a short-circuit of the phases (F) of the electric motor (1) or any of the switches (Ch).

8. A motor according to claim 7, characterized in that the control central (7) indicates a condition of short-circuit of the motor (1) when the time (T_d) is shorter than the time (T_c) multiplied by a factor (k) that varies between 0 and 1, and the central (7) indicates a condition of overload of the motor (1) when the time (T_d) is longer than the time (T_c) multiplied by the factor (k).

9. A motor according to claim 8, characterized in that the factor (k) is equal to 0.5.


1
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Ch3
Ch5
Ch2
Ch4
Ch6
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+Vb
RA
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Co
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E+
RB
+Vb
Ch1 ~ Ch6

FIG. 1

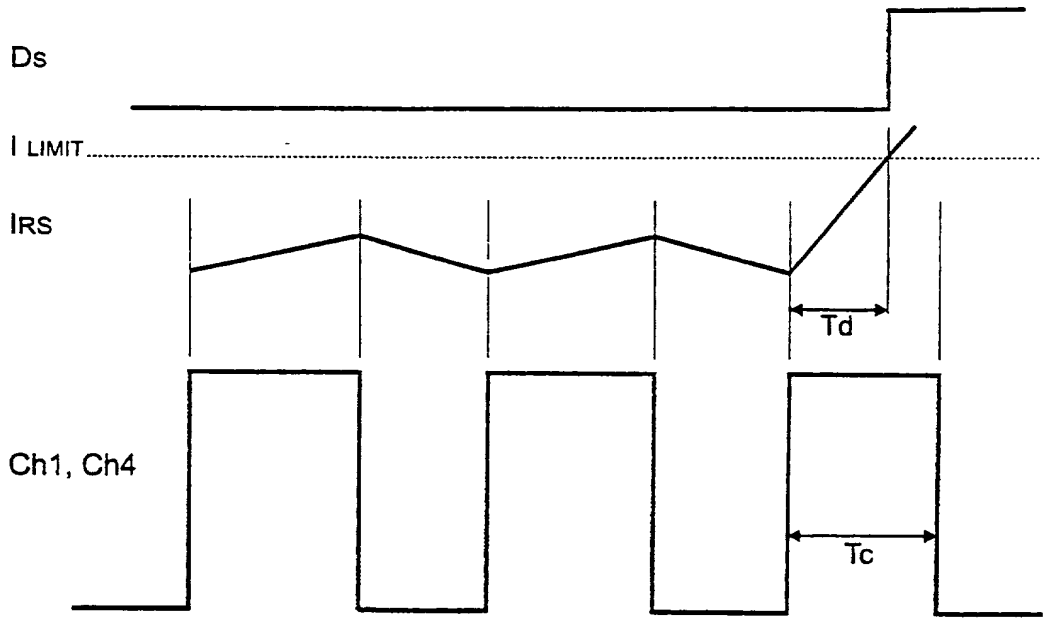

FIG. 2

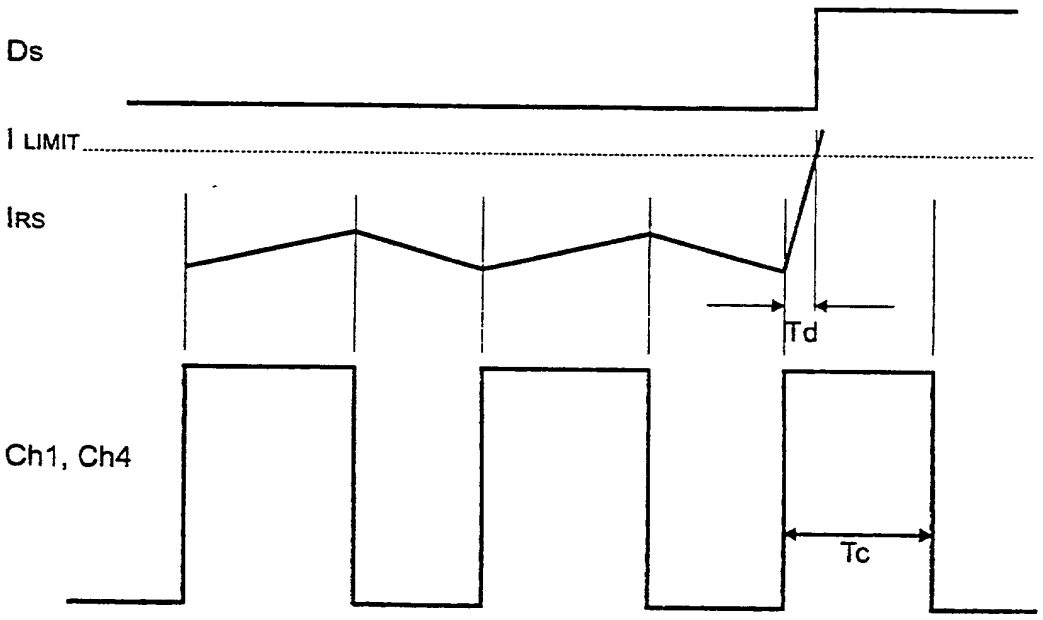

FIG. 3

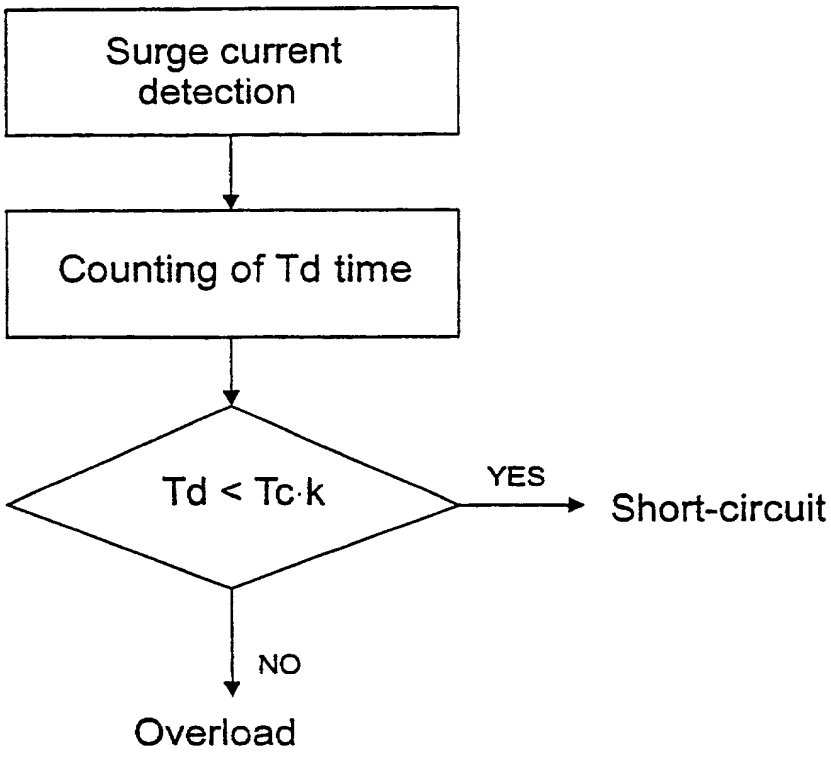
Surge current detection
Counting of Td time
Td < Tc·k
YES
Short-circuit
NO
Overload

FIG. 4

Declaration and Power of Attorney
United States Patent Application

UNITED STATES (Form BDWY 994)
Patents and Design Patents
Sole & Joint Inventors
Convention & Non-convention
PCT & Non-PCT
This form cannot be amended, altered or changed after it is signed
(For use only for inventors who understand the English language)

As a below named inventor, I hereby declare that:
My residence, post office address and citizenship are as stated below next to my name.
I believe I am the original, first and sole inventor *(if only one name is listed below)* or an original, first and joint inventor *(if plural names are listed below)* of the subject matter which is claimed and for which a patent is sought on the invention entitled

A system and a method for protection and electric motor and its control circuit, and an electric motor", the specification of which

(check one)
- ☒ is attached hereto.
- ☐ was filed on May 10, 2001 as U.S. Application Serial No. 09/831,507 and *(if applicable)* was amended on _____.
- ☒ was filed as PCT International Application No. PCT/BR99/00093 on November 11,1999 and *(if applicable)* was amended under PCT Article 19 on _____.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign and PCT application(s) for patent or inventor's certificate listed in this Declaration and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Foreign/PCT Application No.	Country	Filing Date	Priority Claimed? (yes/no)
PI 9804608-0	BR	November 12,1998	yes
PCT/BR99/00093	PCT	November 11,1993	yes

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) and PCT International Application(s) listed in this Declaration and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

U.S. Application No.	Filing Date	*Status (patented/pending/abandoned?)*
PCT/BR99/00093	November 11,1993	

I hereby appoint the following attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith: Joseph A. DeGrandi (17446), Robert G. Weilacher (20531), Richard G. Young (20628), Michael A. Makuch (32263), Bernard A. Meany (22001), Helen M. McCarthy (32513), Dennis C. Rodgers (32936), William F. Rauchholz (34701), G. Byron Stover (34737), Thomas L. Evans (35805), Maurice U. Calm (30454), Robert Jones Worrall (37969), and William J. Bundren (31712).

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

1 - CC Full name of sole or first inventor: MARCOS GUILHERME SCHWARZ Citizenship: Brazilian
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Joinville, Santa Catarina, Brazil
Signature: [signature] Date: JULY 30, 2001

2 - CC Full name of second joint inventor, if any: PAULO SERGIO DAINEZ Citizenship: Brazilian
Residence *(city, state, country)*: Joinville, Santa Catarina, Brazil BRX
Post office address: Rua Rui Barbosa, 1431, apt. 302, Bloco 1
Joinville, Santa Catarina, Brazil
Signature: [signature] Date: JULY 11/2001

BDWY 994 *(Supply similar information and signature for third and subsequent joint inventors.)*